Long-term development of lowland rivers
Rivers2Morrow - a research program

Matthijs P. *Boersema* [a]*, *Evelien van Eijsbergen* [a], *Dirk-Sytze Kootstra* [b], *and Ralph M.J. Schielen* [a]*
[a] *Rijkswaterstaat, Ministry of Infrastructure and Water Management, Griffioenlaan 2, 3526 LA Utrecht, the Netherlands*
[b] *Directoraat-Generaal Water en Bodem, Ministry of Infrastructure and Water Management, Rijnstraat 8, 2515 XP, Den Haag, the Netherlands*

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Introduction

The lowland rivers of the Netherlands -- Rhine, Meuse, Ems and Scheldt -- play a vital role in the Dutch society. Although these rivers are relatively small on a worldwide scale, their watersheds are highly industrialized and densely populate, making their protection and development very important.

As an entity responsible for river policies and management in the Netherlands, the Ministry of Infrastructure and Water Management has the duty to maintain, and facilitate the sustainable development of four river's functionalities that are beneficial to the society at large. These functionalities are: (1) flood risk management (safely discharging water and sediments), (2) providing sufficient amount of fresh water to end users, (3) access to water that is ecologically clean and poses no health hazards, and (4) river navigation. Other river-related functions, such as energy production, cooling-off, fishing, construction materials, agriculture, and so on, are accepted as long the main four river functionalities are not under threat [1].

Since the last decade it is becoming clear that maintaining and developing the four river functions for the longer term, is becoming increasingly challenging and costly. Taking care of local bottlenecks without taking into account the long-term river development is not sufficient. The paragraph below describes the complexity of various factors at stake, both coming from nature and induced by men.

Changing conditions

The large-scale geomorphology of river systems is adapting quite slowly to the changing boundary conditions. For lowland rivers these conditions are: (1) the upstream discharge, (2) the down-stream sea level, (3) the upstream sediment inflow, (4) the stability of bifurcation point, and (5) the present material composition of the river bed. The hydraulic boundary conditions are changing due to the climate change; the sea level is rising and we observe a more extreme water discharge pattern. At the same time, the construction of dams (the upstream part), straightening of the navigation channel, meander cut-offs, construction of groynes, executed in the period 1850-1940, give rise to an imbalance between sediment transport capacity and sediment supply. This causes rapid erosion of the river bed. Measurements in Dutch part of the river Rhine show an erosion rate of 2 cm/year over de last 50 years. This causes problems with navigation depth around places with non-erodible layers, stability of infrastructure, covering depth of river crossing pipelines, lowering of groundwater tables and the impact on nature development, etc. In the river delta we see issues related to the development of erosion holes in the riverbed. Secondly the salt intrusion, especially during low discharge, is an increasing problem.

This combination of changing boundary conditions, past and present human activities makes it unclear what the new equilibrium state on the longer term will be. For new large scale measure in the river system, we would like to know and predict the impact on the river morphology. This is only possible when we understand the current long-term development.

Rivers2Morrow
Working on the Future of our Rivers

The program

To develop deeper insight in the long-term development of the Dutch river systems, and provide new information for adaptive strategies, the Ministry has started in 2017 a research program called Rivers2Morrow [2]. This program will have a duration of six years and will be part of the larger NKWK program, which addresses fourteen themes related to climate adaption issues [3].

This program focuses on geomorphology, hydraulics, and ecology. We would like to find out how lowland rivers respond to climate change, sea level rise and changing river discharge. The sediment supply at the upstream boundary will most probably change, not only as a result of climate change, but also as a result of anthropogenic interference. Furthermore, in many river systems (including the Dutch Rhine branches and the Meuse River), many measures to reduce flood risk have been applied in the past thirty years. Although every individual measure has been designed so as to minimize the morphological changes, the combined morphological effects in the next few decades are still highly uncertain. Also the assessment of ecological changes --succession of vegetation -- and its effects on hydrology and morphology remain challenging.

Rivers2Morrow can be seen as the successor of the research program RiverCare [4]. which in its turn was inspired by the program Room for the River, which among other things explored the morphological and ecological consequences of longitudinal dams, side channels and other restoration measures.

Research questions

The overall research question that we intend to answer is how a lowland river system in general responds to changes, in the course of its evolution towards a new (dynamical) equilibrium. Rhine and Meuse rivers act as case studies and living labs to test a number of theories.

Rivers2Morrow addresses the following six research questions:

1. What is the long-term response of Rhine and Meuse to the sea-level rise and other changing external conditions, and how can we predict that response.
2. How do interactions between water, silt, sand, salt and vegetation determine the long-term development of the deltaic area of lowland river systems, and how can we apply this knowledge .
3. How will the sediment supply towards the delta, the partitioning and spread of sediment within the delta and the composition of the river bed change as a result of changing climate, changing land use, constructions of measures and other influence of other anthropogenic developments.
4. How do the changing boundary conditions, influence the anticipated development of nature and what strategy is increasing the ecological opportunities.
5. What are the hydro-morphological effects of the heterogeneity of the subsoil of lowland rivers on the formation of bedforms (bars and dunes) and bed features (e.g. scour holes) and what is the influence of changing boundary conditions?
6. How can we improve hydraulic, ecological, and morphological models in order to improve their predictive value and expand their predictive horizon?

Progress

Three PhD-candidates will work on research question 1. One PhD-student at Utrecht University has already started addressing the question of sediment management in the deltaic area. A second PhD-student at the TU Delft will start in December 2018 to work on sediment issues in the upper delta. At Wageningen University, a third PhD-student has started her research in the second part of 2018, working on research question 3. She explores new methods to predict sediment transport. Early 2019, a PhD candidate will start working on bifurcation points at the University of Twente, contributing to research question 1 and 3.

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References

[1] Beheer- ontwikkelplan rijkswateren 2016-2021.
[2] https://ncr-web.org/projects/rivers2morrow/
[3] https://waterenklimaat.nl/en/research-tracks/
[4] http://www.rivercare.nl/

* Corresponding authors
Email address: matthijs.boersema@rws.nl (Matthijs Boersema), raph.schielen@rws.nl (Ralph Schielen)